CamScanner

Design of alluvial unlined Canal.

(1) Kennedy theory

→ Kennedy uses trapezoidal section of side slope (½:1)

→ He concluded that eddies are formed from bed of canal and these formed eddies keep the soil in suspension.

→ The eddies are formed due to friction bet soil surface & water.

→ Kennedy gave eqn to find critical velocity

$$V_c = 0.55 M y^{0.64}$$

Where

y = flow depth.

M = critical velocity Ratio (CVR)

$$C.V.R = \frac{V_a}{V_c} \quad \left[\begin{array}{l} V_a = \text{mean velocity} \\ V_c = \text{critical velocity} \end{array}\right]$$

→ He uses Kutter's formula to find mean velocity.

$$V_a = C\sqrt{R \times S} \quad \text{where.}$$

C = Kutter's Constant given as.

$$C = \frac{\frac{1}{n} + \left(23 + \frac{0.00155}{S}\right)}{1 + \left(23 + \frac{0.00155}{S}\right) \times \frac{n}{\sqrt{R}}}$$

i) If $V_a = V_c$ then design is ok.

ii) If $V_a \neq V_c$ then change flow depth(y) and do another trial until $V_a = V_c$.

Lacey theory

→ Based on concept of Regime theory.

→ He stated that "eddies are formed from whole wetted perimeter."

→ Kennedy stated that a channel having no silting & scouring is stable/regime channel but Lacey came out with a conclusion that even though a channel is showing no silting or scouring it may not be stable channel.

→ Hence he defined three regime conditions,

(a) True Regime

(b) Initial regime. (for short period stable)

(c) final regime. for longer period

True Regime:-

for True regime following conditions should be satisfied

1. Flow is uniform.
2. Discharge is constant
3. Silt grade is constant
4. Silt charge is constant
5. Flow takes place through incoherent alluvium.

These Conditions are not practically possible, hence Lacey's defined Initial and final Regime

(a) Initial Regime:-
When bed slope and depth varies and other parameters remains the same then the channel may exibit no silting & no scouring condition called as Initial Regime.

→ This Regime is temporary.
→ Lacey theory is not applicable.

(b) Final Regime:-
When all parameters i.e. bed slope, depth, side slope vary and finally get adjusted accordy to discharge & silt condition then the channel is said to have achieved permanent stability called as final regime.

→ Lacey theory is applicable to final regime condition.

Lacey gave following formula. (Numericals)

$$\text{velocity}(V) = \left(\frac{Qf^2}{140}\right)^{1/6}$$

V = velocity in m/s.
Q = discharge m^3/s.
f = Silt factor.

$$\text{Silt factor}(f) = 1.76\sqrt{d_{50}}$$ [d_{50} = average particle size in mm]

$$\text{wetted perimeter}(P) = 4.75\sqrt{Q}$$

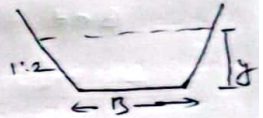
$$\text{Bed slope}(S) = \frac{f^{5/3}}{3340\,Q^{1/6}}$$

Hydraulic depth mean radius $(R) = \frac{5}{2}\frac{v^2}{f}$

$$\text{Scour depth} = 0.473\left(\frac{Q}{f}\right)^{1/3}$$

Q. Design an Irrigation canal in alluvial soil according to Lacey theory using following data.
full supply discharge $(Q) = 10\ m^3/s$.
Lacey's silt factor $= 0.9$
side slope of canal $(S) = H:V = 1:2$ (H:V)

Soln:



$$V = \left(\frac{Qf^2}{140}\right)^{1/6}$$

$$= \left(\frac{10 \times 0.9^2}{140}\right)^{1/6} = 0.62\ m/s.$$

$$\text{Area}(A) = \frac{Q}{V} = \frac{10}{0.62} = 16.12$$

$$\text{wetted perimeter}(P) = 4.75\sqrt{Q}$$
$$= 4.75\sqrt{10} = 15.02 \approx 15$$

$$\text{Area}(A) = By + 2y^2$$

$$16.12 = By + \tfrac{1}{2}y^2 \quad (z = \tfrac{1}{2}) \quad \text{——— (i)}$$

$$P = B + 2y\sqrt{1+z^2}$$

$$15 = B + 2y\sqrt{1+\tfrac{1}{4}}$$

$$B = 15 - 2y\sqrt{5/4} \quad \text{——— (ii)}$$
$$= 15 - \sqrt{5}\,y \quad \text{——— (ii)}$$

$$16.12 = 15y - \sqrt{5}y^2 + 0.5y^2$$

$$16.12 = 15y - 2.23y^2 + 0.5y^2$$

solving above eqn ① & ②

$B = 12.3\ m \; ; \; y = 1.25\ m.$

now, Check.

$R = \frac{A}{P} = \frac{16.12}{15} = 1.074.$

Also $R = \frac{S}{2}\frac{v^2}{f} = \frac{S}{2}\frac{(0.62)^2}{0.9} = 1.067.$

Nearly equal so design is ok.

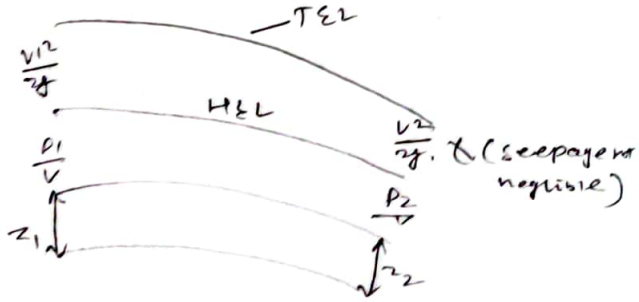
Bed slope $(S) = \frac{f^{5/3}}{3340 Q^{1/6}}$

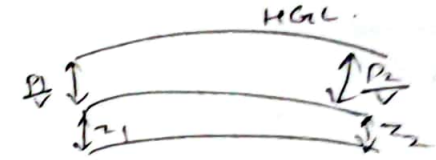
$= \frac{(0.9)^{5/3}}{3340\,(10)^{1/6}}$

$= \frac{(0.9)^{5/3}}{4902.44} = 1.71 \times 10^{-4}$

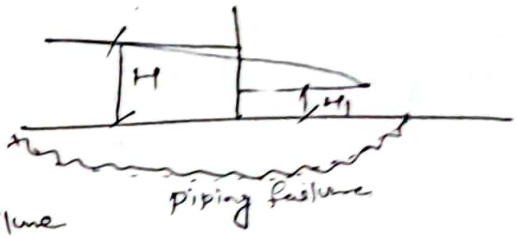
$S = (1 : 5847 \; (\frac{1}{1.71 \times 10^{-4}}.)$

seepage theory.

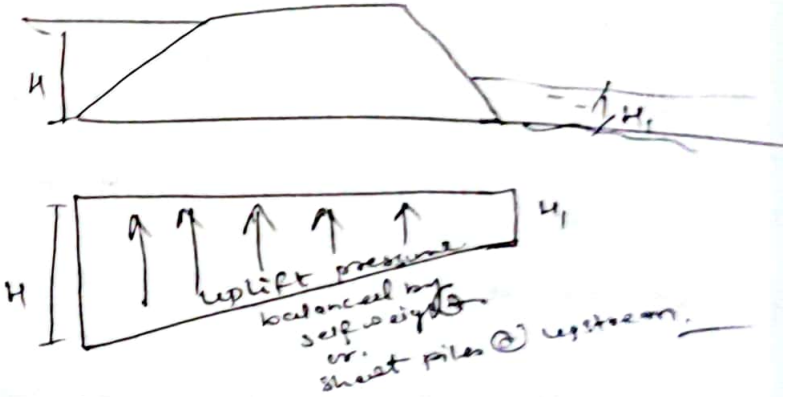




Seepage flow



Rupture failure

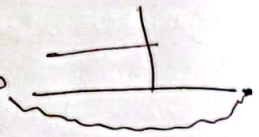


Seepage Analysis

The water seeping below hydraulic structure change the stability of structure and may cause its failure by ⓐ piping or under lining

ⓑ direct uplift

⑤ failure by piping:-



→ If the water percolating below foundation of hydraulic structure as sufficient energy when it emerges downstream end of the floor, it may uplift the soil particles at the end floor.

→ The process of erosion extends backwards to U/S side & results in removal of soil particles developing a pipe like structure below floor.

→ The floor subsides in vacant space resulting in failure of structure.

To prevent piping failure.

① providing sufficient length of impervious floor so that path of seepage is increased and exit gradient is reduced.

② providing sheet piles cutoff.

→ This increase length of seepage & hence reduces the exit hydraulic gradient.

Hydraulic gradient (i) = $\frac{H}{L}$

→ The hydraulic gradient at exit is called as exit gradient or exit hydraulic gradient

⑥ Direct uplift:

→ The water percolating below the foundation exert upward force on impervious floor due to residual head known as uplift pressure.

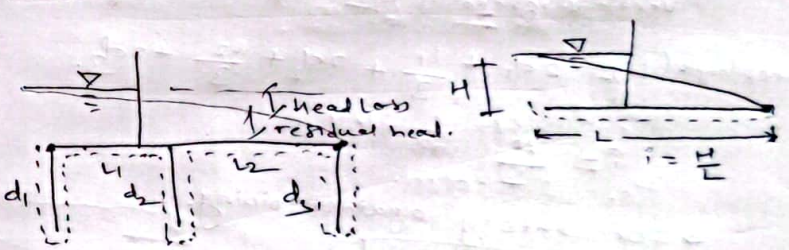
→ If this uplift pressure is not counter balanced by weight of structure, then the structure may fail due to rupture.

prevention.

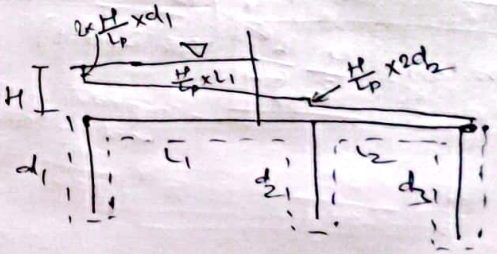
① providing sufficient thickness of impermeable foundation.

② providing sheet piles at the U/S side of impervious floor.

① Bligh's creep theory



creep length (L) = $2d_1 + L_1 + 2d_2 + L_2 + 2d_3$



$L_p = H$

$i = \frac{H}{L_p}$

$d_1 = \frac{H}{L_p} \times d_1$

Assumptions

(1) percolating water follows outline of the base of foundation of hydraulic structure.

(2) → Length of path traveled is called as creep length.

(3) The head loss per unit creep length is constant whether it is vertical or horizontal.

(4) Total head loss between U/S and D/S is H and creep length be L then the head loss per unit creep length ($\frac{H}{L}$) is called as hydraulic gradient.

~~Bligh's theory:-~~

01/10/2079 Irrigation

Lay's theory:-

Vertical creep is more effective by 3 times.

creep length (L_f) $= 2d_1 + \frac{l_1}{3} + 2d_2 + \frac{l_2}{3} + 2d_3$.

$i = \frac{H}{L}$

→ For safety against piping.

$$\frac{H}{L} \leq \frac{1}{C}$$

$$\text{Thickness } (t) = \frac{H}{3}\frac{h'}{G-1}$$

(h' = Residual head (for uplift), G = Sp. gravity of material used in flooring)

5.

Here C =

Bligh's Constant = 15 & Lane C = 8.5

Using Bligh's and Lane's theory

(a) Determine hydraulic gradient

(b) Check safety against piping

(c) Determine floor thickness at A & E

Soln

(1) Using Bligh's theory.

Creep Length (L_f) =

= 63 m

(a) Hydraulic gradient (i) = $\frac{H}{L} = \frac{H}{63}$

(b) Safety against piping

$$\frac{H}{L} \leq \frac{1}{C}$$

$$\frac{H}{63} \leq \frac{1}{15}$$ (Hence safe against piping)

(c)

(c)

For point A.

$63 \rightarrow 4$

$1 \rightarrow 4/63$.

$(2\times6+15)\ 27 \rightarrow \frac{4}{63}\times27$

$\therefore$ Residual head at A $= H - \frac{H}{L}\times L_A$

$\therefore$ Residual head at A $= 4 - \frac{4}{63}\times(2\times6+15)$

$= 4 - \frac{4}{63}\times27$

$\therefore H_A = 2.28$ m.

$H_B = 4 - \frac{4}{63}\times(2\times6+15+10)$

$= 4 - \frac{4}{63}\times37$

$\therefore H_B = 1.65$ m

$H_C = 4 - \frac{4}{63}\times47$

$H_C = 1.01$ m.

$\therefore$ Thickness at A $(t_A) = \frac{4}{3}\frac{h}{G-1}$

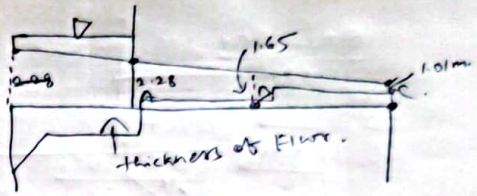
$= \frac{4}{3}\left(\frac{2.28}{2.24-1}\right) =$

$\therefore t_A = 2.45$

$t_B = \frac{4}{3}\left(\frac{1.65}{2.24-1}\right) = \frac{4}{3}\times\frac{1.65}{1.24} = 1.77$ m.

$t_C = \frac{4}{3}\left(\frac{1.01}{1.24}\right) = 1.08$ m.

(2) Lane



(a) Lane's theory

creep length $(L_2) = 2\times6 + \frac{15}{3} + \frac{10}{3} + \frac{10}{3} + 2\times8$

$= 12 + \frac{35}{3} + 16$

$= 39.66$ m.

(b) Hydraulic gradient $(i) = \frac{H}{L_2} = \frac{4}{39.66}$

(b) safety against piping

$\frac{H}{L} \le \frac{1}{C_L} \Rightarrow \frac{4}{39.66} \le \frac{1}{8.5}$ (Hence safe)

$(0.10 \le 0.117)$

(c) Thickness.

Residual head at A $(H_A) = H - \frac{H}{L}\times(12+\frac{15}{3})$

$= 4 - \frac{4}{39.66}\times17$

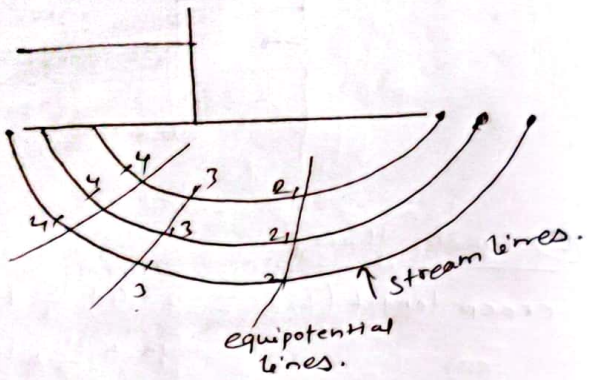
$= 2.28$ m.

thickness at A $(t_A) = \frac{4}{3}\left(\frac{2.28}{2.24-1}\right)$

$= \frac{4}{3}\times\frac{2.28}{1.24}$

$\therefore t_A = 2.45$ m.

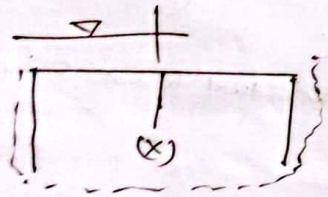
Khosla's theory.



if exit gradient $>$ critical gradient then safe against piping.

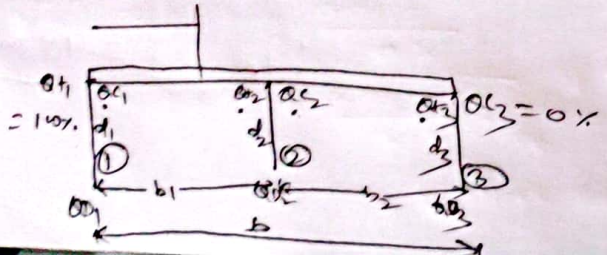
→ Outer sheet piles plays major role.

→ if intermediate pile length is less than others then there is no any use of intermediate pilesheet.



→ $i_{exist} < i_{critical}$

$i_{exist} < \left(\frac{1}{4} \text{ to } \frac{1}{5}\right) i_{critical}$



For pile no 1

$\phi_{D_1} = \frac{1}{\pi}\cos^{-1}\left(\frac{1-\lambda}{\lambda}\right)$ } percentage of residual pressure

$Q_{C_1} = \frac{1}{\pi}\cos^{-1}\left(\frac{2-\lambda}{\lambda}\right)$ } $\lambda = \frac{1+\sqrt{1+\alpha^2}}{2}$, $\alpha = \frac{b}{d}$

For pile 2 (Intermediate pile)

$Q_{t_2} = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda_1 - 1}{\lambda}\right)$

$Q_{D_2} = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda_1}{\lambda}\right)$

$Q_{C_2} = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda_1 + 1}{\lambda}\right)$

$\Rightarrow \lambda_2 = \frac{\sqrt{1+\alpha_1^2} + \sqrt{1+\alpha_2^2}}{2}$

$\lambda_1 = \frac{\sqrt{1+\alpha_1^2} - \sqrt{1+\alpha_2^2}}{2}$

$\alpha_1 = \frac{b_1}{d_2}$

$\alpha_2 = b_2/d_2$

For pile 3.

$Q_{t_3} = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda - 2}{\lambda}\right)$; $\lambda = \frac{1+\sqrt{1+\alpha^2}}{2}$

$Q_{D_3} = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda - 1}{\lambda}\right)$

$\alpha = \frac{b}{d_3}$.

Corrections applied :-

(a) correction due to mutual interference :-

$$C = 19\sqrt{\frac{D}{b'}}\left(\frac{d+D}{b}\right)$$

b' = dist. bet^{n} piles.

b = Total floor length.

D = Depth of pile whose inference has to be consider.

d = depth of pile on which effect is considered

+ve for Back effect

-ve for Forward effect.